Projectile Motion:

- X- and Y-directions are independent
- Object in free-fall (y-direction)
- Ignore air resistance
- No acceleration in x-direction
- Only acceleration in y-direction is acceleration due to gravity
- x- and y-directions connected by time

Variable	Units
Δx	m
Δy	m
V_{ix}	m/s
V_{iy}	m/s
V_i	m/s
a_g	m/s^2
t	s
θ_i	degrees
θ_f	degrees
V_f	m/s
V_{fx}	m/s
V_{fy}	m/s

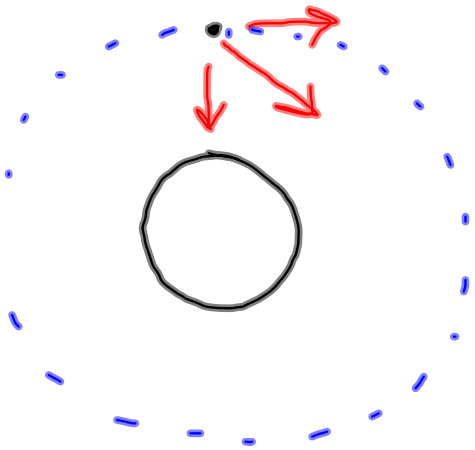
Equations:

$$\Delta x = v_{ix} t$$

$$\Delta y = v_{iy} t + \frac{1}{2} a_g t^2$$

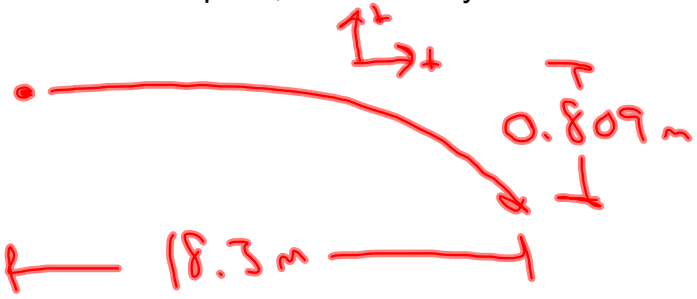
$$v_{fy}^2 = v_{iy}^2 + 2 a_g \Delta y$$

$$v_{fy} = v_{iy} + a_g t$$



Objects in orbit are constantly falling freely.

The fastest recorded pitch in Major League Baseball was thrown by Nolan Ryan in 1974. If this pitch were thrown horizontally, the ball would fall 0.809 m by the time it reached home plate, 18.3 m away. How fast was Ryan's pitch?



$v_{i,x} = ?$

$v_{i,y} = 0\ m/s$

$a_g = -9.8\ m/s^2$

$a_x = 0\ m/s^2$

$t = ?$

$$\Delta y = v_{i,y}^{0} t + \frac{1}{2} a_g t^2$$

$$t = \sqrt{\frac{2\Delta y}{a_g}}$$

$$= 0.406\ s$$

$$\Delta x = v_{i,x} t$$

$$v_{i,x} = \frac{\Delta x}{t}$$

$$= 45.1\ m/s$$

A shell is fired from the ground with an initial speed of 1.70E3 m/s at an initial angle of 55 degrees to the horizontal and returns to the ground. Neglecting air resistance, find
a) the shell's horizontal range.
b) the amount of time the shell is in motion.

$$v_{ix} = v_i \cos(55°)$$
$$= 975 \text{ m/s}$$
$$v_{iy} = v_i \sin(55°)$$
$$= 1393 \text{ m/s}$$

b) $$v_{fy} = v_{iy} + a_g t$$

$$t = \frac{v_{fy} - v_{iy}}{a_g}$$

$$= \frac{-1393 \text{ m/s} - 1393 \text{ m/s}}{-9.8 \text{ m/s}^2}$$

$$= 284 \text{ s}$$

a) $$\Delta x = v_{ix} t$$

$$= (975 \text{ m/s})(284 \text{ s})$$

$$= 2.77E5 \text{ m}$$

A person standing at the edge of a seaside cliff kicks a stone over the edge with a speed of 18 m/s. The cliff is 52 m above the water's surface.
a) How long does it take for the stone to fall to the water?
b) With what speed does it strike the water?